RELATIONSHIP OF COMPONENTS IN HOMOGENEOUS PLUTONIUM MIXTURES

A general approach is to define a solution or mixture as a sum of the fractional volumes, e.g.:

$$1.0 = \frac{\rho_1}{\rho_1^o} + \frac{\rho_2}{\rho_2^o} + \frac{\rho_3}{\rho_3^o} \cdots$$

where ρ is the density of a material in the mixture and ρ^o is the density of a material with no other materials present. Using this relationship, a general equation may be derived for uranium and plutonium solution or mixtures:

$$H/(Pu+U) = \frac{0.1110\left(1000 - \left\{A_{H^+}\left[\frac{(1-G')}{\rho^o_{H^+u}} + \frac{G'}{\rho^o_{H^+pu}}\right] - 9.010\right\}M\right)}{\left[(1-G')\sum_{i=1}^{u}\frac{f_i}{A_i} + G'\sum_{j=1}^{pu}\frac{f_j}{A_j}\right]g(U+Pu)/\ell}$$

$$-\left[\frac{\frac{(1-G')}{F_u\rho^o_{ux}} + \frac{G'}{F_{pu}\rho^o_{pux}}}{(1-G')\sum_{i=1}^{u}\frac{f_i}{A_i} + G'\sum_{j=1}^{pu}\frac{f_j}{A_j}}\right]0.1110$$

where:

A_{H^+} = Molecular weight of acid (or other material)

A_i = Atomic weight of uranium isotope

A_j = Atomic weight of plutonium isotope

M = Acid Molarity

f_i = Weight fraction of uranium isotope in uranium

f_j = Weight fraction of plutonium isotope in plutonium

ρ^o_{ux} = Full theoretical density of uranium compound, e.g., 10.96 for UO_2

ρ^o_{pux} = Full theoretical density of plutonium compound

F_u = Weight fraction of uranium in uranium compound

F_{pu} = Weight fraction of plutonium in plutonium compound

$\rho^{\circ}_{H^+}$ = 100 percent acid density*

G' = Weight fraction of plutonium in total uranium plus plutonium

$$= \frac{1}{1 + \frac{F_u}{F_{pu}} \left(\frac{1}{G} - 1 \right)}$$ where G = weight fraction of Pu compound

in total compound, e.g., PuO_2 in $PuO_2 + UO_2$.

0.1110 = 2/molecular weight of water = 2/18.02

9.010 = molecular weight of water/2 = 18.02/2

*The effective value varies with the experimental work, see next page.

Various values may be inserted into the general H/U+Pu equation to obtain a particular equation for the materials used. Some values that may be used are shown in the following table:

USEFUL VALUES FOR GENERAL H/X EQUATION

Symbol	PuO_2	UO_2	UO_3	$Pu(NO_3)_4$	$UO_2(NO_3)_2$
$\rho^{\circ}_{H^+}$	-	-	-	1.9053*	1.9683**
ρ°_{pux}	11.46(th.)	-	-	5.629*	-
F_{pu}	0.8819	-	-	0.49079	-
ρ°_{ux}	-	10.96(th.)	8.34(th.)	-	5.1657**
F_u	-	0.8815	0.8322	-	0.60409
A_{H^+}	-	-	-	63.0147	63.0147

*Obtained from least squares fit of solutions analyses - C. R. Richey, Nuclear Science and Engineering, Vol. 31, No. 1, 1968.

**Derived from the equation $\rho_{sol} = 1.0012 + 0.3177\ M_{UNH} + .03096\ M_{H^+}$.

Using the above values we can derive the following particular equations for plutonium systems:

$Pu-H_2O$

$$H/Pu = \left(\frac{26535}{gPu/\ell} - 1.3538\right) \Big/ (f_{239} + .99583f_{240} + .99170f_{241})$$

Pu Nitrate

$$H/Pu = \left(\frac{26535 - 638.5M}{gPu/\ell} - 9.605\right) \Big/ (f_{239} + .99583f_{240} + .99170f_{241})$$

$(PuO_2+UO_2)-H_2O$

$$H/(Pu+U) = \frac{\frac{26535}{g(Pu+U)/\ell} - 26.535\ (.10351-.004565G')}{(1-G')(1.01706f_{235} + 1.00420f_{238}) + G'(f_{239} + .99583f_{240} + .99170f_{241})}$$